II BSC SEMESTER-III

Heat and Thermodynamics

PHYSICS PRACTICAL MANUAL

(PAPER III)

2022-2023

Department of Physics

Sri Y.N. College (A)

Narsapur

TEMPARATURE COEFFICIENT OF RESISTANCE OF THERMISTER

Aim: To drawn the resistance temperature curve of a Thermistor and determine the temperature coefficient of resistance of the Thermistor.

Apparatus: Thermistor, thermometer, battery, galvanometer, voltmeter, and plug key and Resistance boxes.

Formula: Temperature coefficient of resistance of the Thermistor

$$\propto = \frac{1}{R} \times \frac{\Delta R}{\Delta T} \times 106 \quad \text{ppm / K}$$

$\propto$ = Temperature coefficient of resistance of the Thermistor (ppm/K)

ΔR = Change in Resistance (Ω)

ΔT = Change in temperature (K)

R = Average Resistance (Ω)

Theory:

A Thermistor is a thermally sensitive resister whose resistance varies with temperature. The Thermistor is a thermally sensitive resistance, the temperature coefficient of which is large and negative. They are essentially semiconductors which behave as resistors with a very high negative temperature coefficient of resistance.

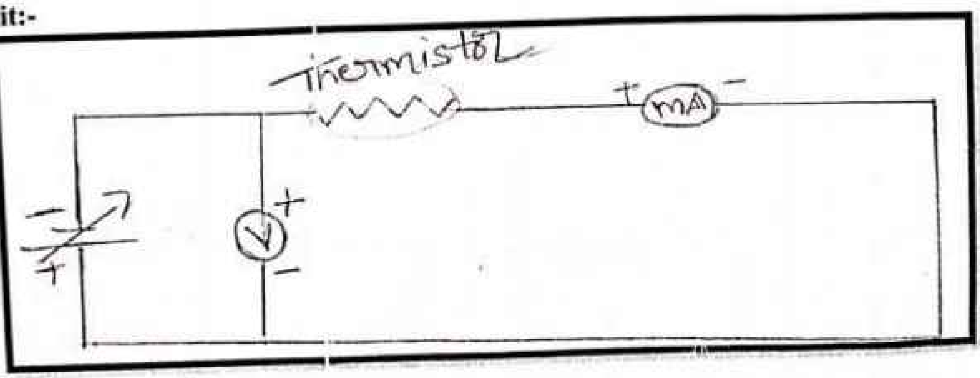
Procedure:-

Temperature V/s Resistance characteristics:

1. Connect the circuit as shown in Fig. through patch cords i.e., connect positive end of power supply to one end of Thermistor to positive end of milliammeter, negative end of milliammeter to negative end of power supply.

2. Switch ON the instrument using ON/OFF toggle switch provided on the front panel, keeping the heater control switch to OFF position.

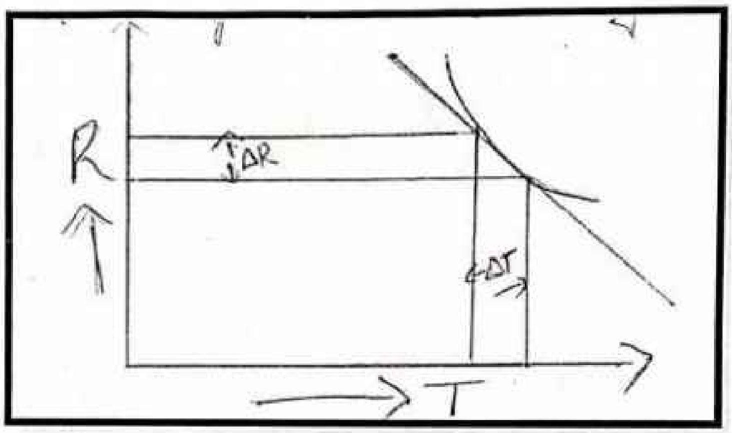
Circuit:-



1

3. Adjust the voltage at 2 volts
4. Note down the temperature in thermometer and current in ammeter.
5. Calculate the resistance of a Thermistor by using formula R = V/ I.
6. Switch ON the heater through switch.
7. Note down the current (I) at different temperatures keeping voltage constant and calculate the value of R.
8. Repeat this experiment 4 – 7 for different value of voltages i.e., 4V, 6V etc.,
9. Plot a graph between temperature and resistance for different voltage as shown in fig.

Graph:-



Precautions:

1. Connection must be tight
2. Heating must be done slowly.
3. The initial temperature and final temperature of thermistor must be measured accurately.

Observations for temperature Vs current:

Sl.No.	Temparature		Milli Ammeter Reading I = mA	Resistance R = V / I Ω
	t^0c	$T=273+t^0c$		

Result:-

Temperature coefficient of resistance of the Thermistor ∝ = ppm / K

2

DETERMINATION OF 'J' – JOULE'S CALORIMETER

Aim: To determine the mechanical equivalent of heat 'J' by Joule's caloric method.

Apparatus: Storage Battery, Ammeter, Adjustable resistance, Key, Voltmeter, Resistance and calorimeter, a stop clock.

Formula: Mechanical equivalent of heat J is given by

$$J = \frac{ECT}{[W_1 S + (W_2 - W_1)](t2 - t1)} \quad \text{joule/cal}$$

W_1 = weight of the calorimeter = gm

W_2 = weight of the calorimeter + water = gm

t_1 = Initial temperature = °C

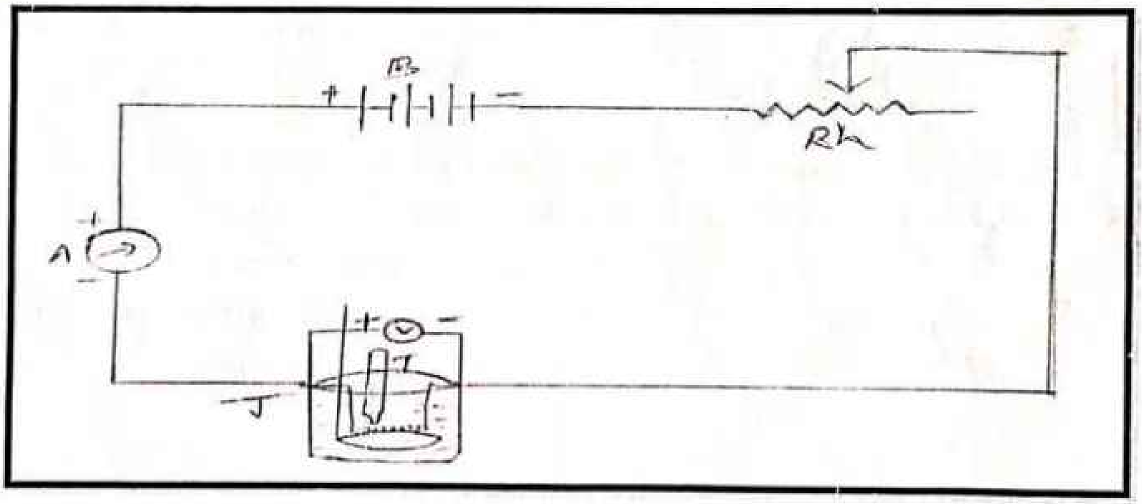
t_2 = Final temperature = °C

E = Voltage applied = volts

C = Current applied = amps

t = Time of flow of current = sec

s = specific heat of material the Joule calorimeter = 0.1 cal/gm



Description:- The heating coil in Joule's calorimeter consists of a coil of fine wire connected by means of short copper wires to two binding screws fitted to an elongated disc which forms the lid of the calorimeter. There is a whole through the centre of the disc for introducing a thermometer for noting the temperature of the contents of the calorimeter. There is another hole in the disc through which a stirrer passes.

3

Procedure: The empty calorimeter with stirrer is weighed and then it is filled with water upto some extent. Then the weight of the calorimeter with stirrer and water is noted. The connections are made as shown in the diagram. The circuit is completed and the adjustable resistance is so arranged so that the ammeter reads a reading 0.9. Then the circuit is cut off and the water is stirred well. Then the thermometer is introduced through the centre hole of the disc and temperature t1 is noted. Then the circuit is again completed and simultaneously a stop clock is started. The water is stirred well with the stirrer. The temperature rise is carefully to be noted. After a rise of 50C of the temperature the stop clock is to be stopped and the time in seconds for the rise of temperature is noted. The voltage of current is noted with the help of voltmeter. The ammeter reading refers to the current passed. Then the mechanical equivalent of heat 'J' is calculated from.

Where E refers to voltage, C is ammeter reading T time noted, t1 initial temperature, t2 final temperature W1 weight of the empty calorimeter with stirrer W2 weight of the calorimeter with water and stirrer and 's' is the specific heat of the material of the calorimeter.

Table:

S. No	Voltage (E) volts	Current (C) Amp	Initial Temp °C	Final Temp °C	t_2-t_1	Time (t) sec	J J/cal

Precautions: 1. The water is to be well stirred during the experiment.

2. The water is to be taken to such an extent so that the resistance coil will well increase in water.

Result: Mechanical equivalent of heat J =

4

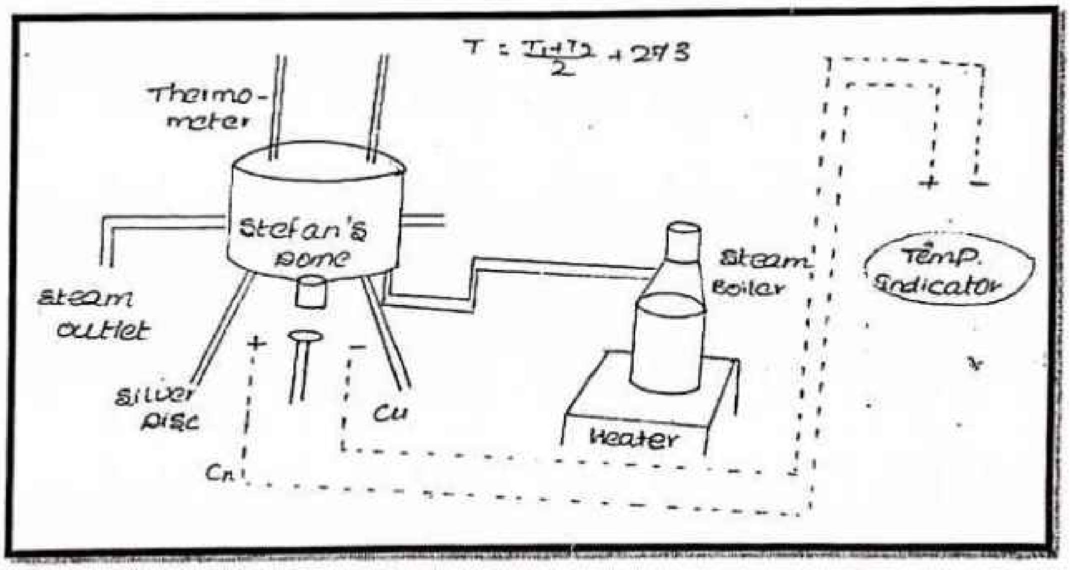
STEFAN'S CONSTANT

Aim: To determine the Stefan's constant (σ) using a black body radiation chamber.

Apparatus:- Stefan's constant, Two thermometers, Temperature Indicator, Digital stop watch, Thermo couple, Electric heater, steam boiler and borosil beaker 500 ml.

Formula: $$\sigma = \frac{J}{A}\left[\frac{ms\left[\frac{dT}{dt}\right]}{T_2^4 - T_0^4}\right] \text{ erg cm}^{-2}\text{K}^{-4}\text{s}^{-1}$$

where σ is Stefan's constant
T_0 is steam temperature in K
T_2 is steady temperature in K
dT/dt is time rate of change of temperature
Mass of silver disc m = 2850 gm
Specific heat of silver s = 0.056 cal/gm
Mechanical equivalent of heat J = 4.18×10^7 erg/cal
Area of the Disc A = 1.54 cm^2



Determination of Stefan's Constant:-

Pass the stem through the steam boiler till the temperature T1. T2 attain steady values. Then turn the stopper aside and insert the silver disc at the base of hemispherical dome and immediately start the stop watch.

Record the temperature indicator readings with time at 5 seconds interval for about 2 minutes.

5

Plot temperature T versus time t. Evaluate the average temperature of the radiating dome using. Find the slope at early time dT/dt. Read the temperature 'T_0' where the slope was taken from graph.

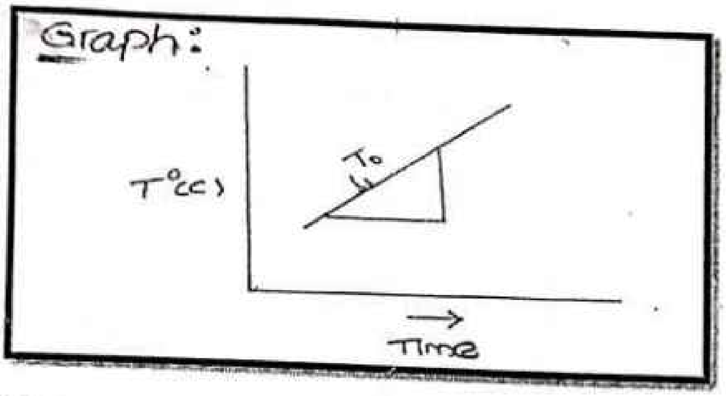


Table:-

Sl.No.	Time (t sec)	Temperature ($T\ ^0C$)

Observations:-

Mass of silver disc	m	=	gms
Disc Radius	r	=	cms
Area of the Disc	A	=	cm2
Specific heat of silver	s	=	

$J = 4.18 \times 10^7$ ergs/cal

Precautions:

1. Temperature should be recorded with utmost accuracy
2. The steady state temperatures should be noted only when the reading of T_0 and T_2 remain constant for about 5 minutes
3. The graph should be drawn with proper scale on both the axes.

Result:

Stefan's constant σ = erg $cm^{-2} K^{-4} s^{-1}$

~~cal/sec/cm^2/unit temperature gradient.~~

6

HEATING EFFICIANCY OF ELECTRIC KETTLE

Aim: To study the heating efficiency of an electric kettle with varying voltages.

Apparatus: A electric kettle, thermometer, variable AC voltage power supply complete with voltmeter, stopwatch and water.

Formula:-

The heating efficiency of the kettle.

$$\eta = \frac{m \: X \: 4.2 \: X \: 10^3 \: X \: \theta \: X \: R}{V^2 t} X \: 100\%$$

Where,

m = mass of the water (W_2-W_1) in gr
V = Voltage applied in volts
t = Time of flow of current in sec
R = resistance of the coil of the kettle in ohm
θ = Rise in temperature (θ_2 - θ_1) ^{o} C
η = Heating efficiency of the kettle in percentage
θ_1 = Initial temperature (^{o} C)
θ_2 = Final temperature (^{o} C)

Theory:-

If m kg of a water taken in a kettle is heated by filament of resistance R ohm at a voltage V volt for time t second, so that the temperature of water rises by θ^0C then assuming that the heat capacity of container is negligible and there is no loss of heat by the conservation of energy.

Electric energy supplied to the heater = Heater energy gained by the water

(or)

$$\frac{V^2 t}{R} = m \: x \: 4.2 \: x \: 10^3 \: x \: \theta$$

Here specific heat of water is taken to be 4.2 x 10^3 J / Kg ^{0}C thus if we that the resistance R of heater almost remains unchanged in the given temperature change (since temperature coefficient of resistance is very low) then for the given values if t and m.

$$\theta \: \alpha \: V^2$$

Hence the rise in temperature of a given mass of water in a given time interval is directly proportional to the square of voltage at which current is passed through the heater. A graph plotted for θ Vs V^2 will be taken be a straight line. But due to loss of heat energy by radiation,

7

at a low voltage, the rise in temperature will be very small and it will not be proportional to the square of voltage. then

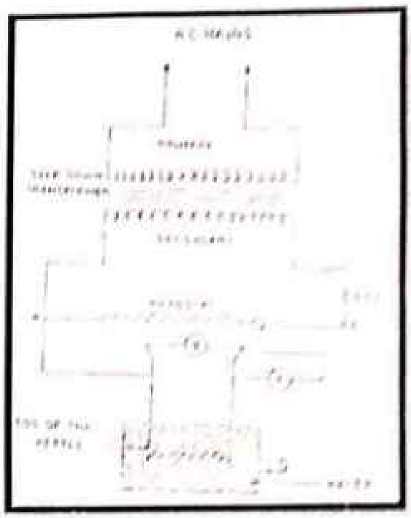
Heating efficient of kettle

$$\eta = \frac{Out\ put\ heat\ energy}{Input\ Electric\ energy} \times 100\,\%$$

$$\eta = \frac{m \times 4.2 \times 10^{3} \times \theta \times R}{V^{2} t} \times 100\,\%$$

Thus at low voltage, the heating efficient of the kettle will be very low.

Procedure:-



1. Measure the resistance R of the given heater by means of multi meter and note it.
2. Take ½ liter (i.e., ½ kg) of water in the kettle container.
3. Note the initial temperature of water by means thermometer.
4. Switch on the power supply and adjust its voltage 100 volt and start the stop clock. After 2 minutes, note the temperature of water.
5. Then change the voltage by means of the variable power supply and adjust it 120 volt. Note the temperature of water after 2 minutes.
6. Repeat the above steps for 140, 160, 180 and 200 volts and at each voltage find the rise in temperature of water after each 2 minutes.

Table:-

Resistance of the filament of electric kettle = 85 Ω

Voltage V (in volt)	Time t (in sec)	Initial temp. of water θ_1 (in ^{0}C)	Final temp. of water θ_2 (in ^{0}C)	Rise in temperature $\theta = (\theta_2 - \theta_1)$	$\eta = \frac{m \times 4.2 \times 10^{3} \times \theta \times R}{V^{2} t} \times 100\,\%$

8

Calculation:-

$W_1 =$ gm $W_2 =$ gm

$m = W_2 - W_1 =$

R = V = t = M =

$$\eta = \frac{m \, X \, 4.2 \, X \, 10^3 \, X \, \theta X R}{V^2 t} X \, 100 \, \%$$

Precautions:-

1. The temperature of water should be noted carefully.
2. Current should be passed through the kettle only after the kettle is properly immersed in water
3. Voltage should (v) remain constant throughout the experiment
4. The temperature should not exceed more than 90^0C

Result: The efficiency of an electric kettle for varying voltages = $\eta =$

9

PLANK'S CONSTANT

Aim: To determine the value of plank's constant (h) by using stopping potential of different filters.

Apparatus: The photo electric cell, power supply, source of light, filters.

Formula:- $h = \frac{e\,(V_2 - V_1)\,\lambda_1 \lambda_2}{C\,(\lambda_1 - \lambda_2)}$ joule - second

Where,

e = electric charge = 1.6×10^{-19} coulombs

C = speed of light = 3×10^{10} cm/sec

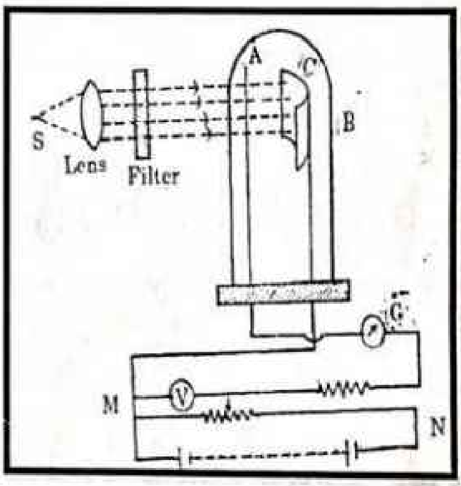
V_1= stopping potential of corresponding to wave length with filter-I (volts)

V_2= Stopping potential of corresponding to wave length with filter-II(volts)

λ_1= Wave length of filter – I (cm)

λ_2= Wave length of filter – II (cm)

Description:-



If light is incident on certain metals, electrons are emitted. These electrons are called photo electrons and the metal is known as photo metal. This emission of electrons by the action of light on metals is called photo electric effect. The photo electric cell consists of a glass or quartz bulb B according as it to be used with visible on ultraviolet light. C is a silver cathode in the form of a semi cylindrical plate. The anode A is a rod mounted vertically at the centre of the bulb and parallel to its axis. A positive potential of about 100 volts is applied to the anode. The negative being connected to the cathode through the galvanometer. When light falls on the cathode C electrons are emitted from it and a small current flows through the circuit as measured by the galvanometer.

10

Theory:-

According to Einstein, light of frequency v consists of a stream of photons each of energy hv. When a photon of frequency v is incident on a metal, the energy of the photon is completely transferred to the free electron in the metal. A part of the energy acquired by the electron is used to pull out the electron from the surface of the metal and the rest of it is used in imparting kinetic energy to the electron. It W_0 is the energy spent in extracting the electron from the emitter to which it is found and ½ mv2 is the kinetic energy acquired by the electron, then

$$hv = W_0 + \frac{1}{2} mv^2$$

Where v is the frequency of the incident radiation and h is plank's constant. W_0 is called the work function of the metal. This equation is known as Einstein photo electric equation.

The stopping potential (V_s) is defined as the necessary retarding potential difference required to just stop the most energetic photo electron emitted.

$$eV_s = \frac{1}{2} mv^2$$

So photo electric equation takes the form

$$hv = W_0 + eV_s$$

If v_0 is the threshold frequency, $W_0 = hv_0$

$$hv = hv_0 + eV_s$$

$$V_s = (h/e)\, v - (h/e)\, v_0$$

So a graph between stopping potential V_s and v the frequency of the incident light is a straight line in the form y+ mx=c.

The slope of the straight line is given by $m = h/e$

$$h = m.e \quad \text{J-S}$$

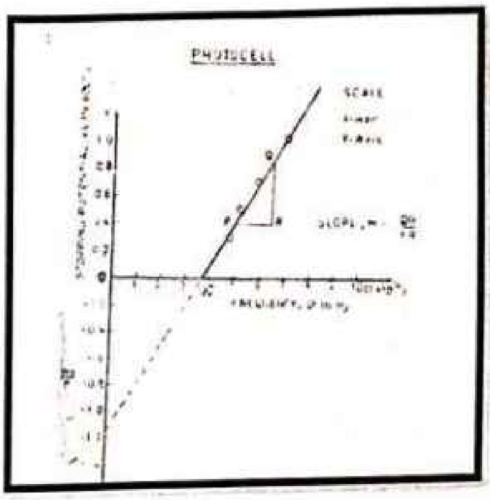
Procedure:-

The circuit is connected as shown in above fig. MN is the potential divider. The potential applied between C & A is measured by a vacuum tube voltmeter VTVM. A series protective resistance is included in the circuit. The current is detected using a ammeter.

Light from a powerful source of light S is condensed by a condenser lens. It is then made to pass through an optical filter. The filter allows light of a fixed frequency to be incident on the photo metal. The potential divider is adjusted so that the ammeter shows zero current. The value of this potential difference is noted.

11

The experiment is repeated using a number of optical filters and the corresponding values of the stopping potentials are found. A graph is drawn between the known frequencies and corresponding stopping potential.



From the graph, the slope m = $\frac{dy}{dx}$ = is calculated.

h = m.e J-S

h = Plank's constant

e = Charge of electron

The observations are tabulated as shown below.

S. No.	Color of the filter	Wave length λ cm	Frequency of incident light, ν Hz	Stopping potential V_s ((in volts)

Precautions:-

1. The stopping voltage should decrease as wave length increases
2. The experiment should be performed with at least three filters.
3. A smooth straight line passing through most of the data points should be plotted.

Result: Plank's constant (from graph) =

Plank's constant (calculated) =

12

6. Thermal Conductivity of Bad Conductor lee's Method

Expt. No. 6 Date Page No. 19

Aim :-

To determine the Cefficient of thermal Conductivity of the material of a Bad Conductivity of the material like Card board carborite, glass etc by lies.

Apparatus :-

lies apparatus steam generator, two thermometer bad Conductor in the form of a disc, Screw guage, Verner callipers, rough, balance and a step watch.

Formula :-

Ceffient of thermal Conductivity of the given Conductor

$$K = \frac{mst\alpha\,(r+2d)}{2\pi r^2 (r+d)(\theta_1-\theta_2)}$$ cal/sec/cm²/unit temperature graduate.

where

K = Cefficient of thermal Conductivity of the give and Conductor to be determined.

m = mass to be determined

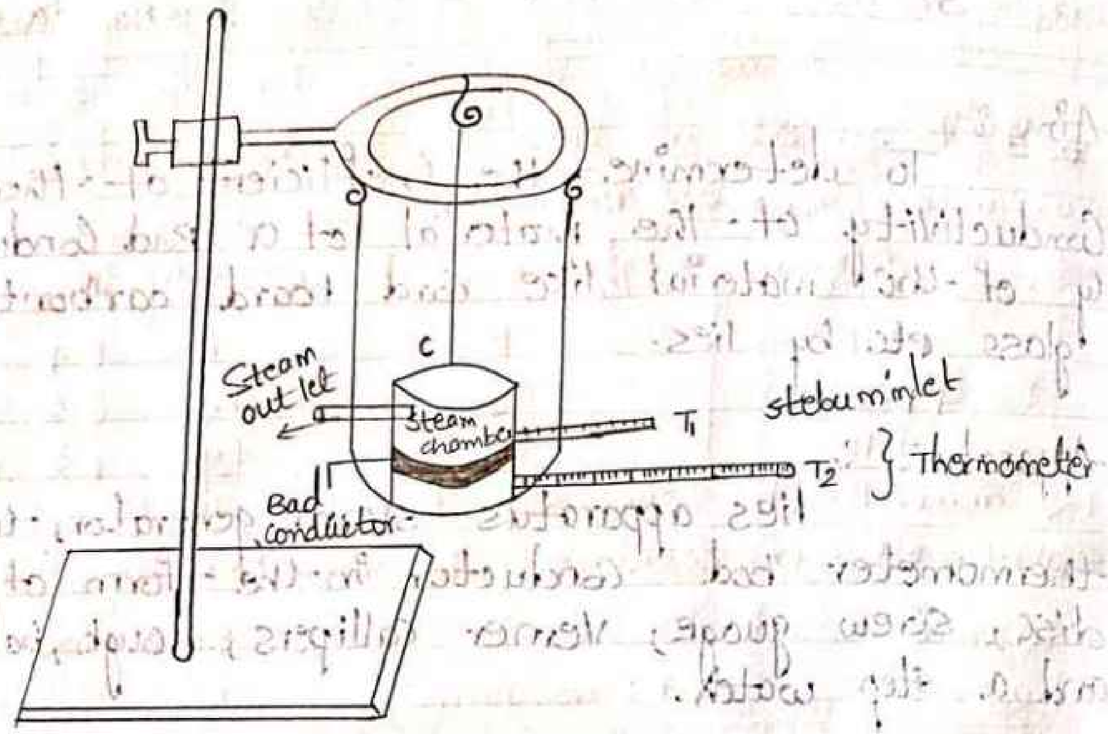
t = thickness of the bad Conductor (cm)

d = thickness of the brass disc (cm)

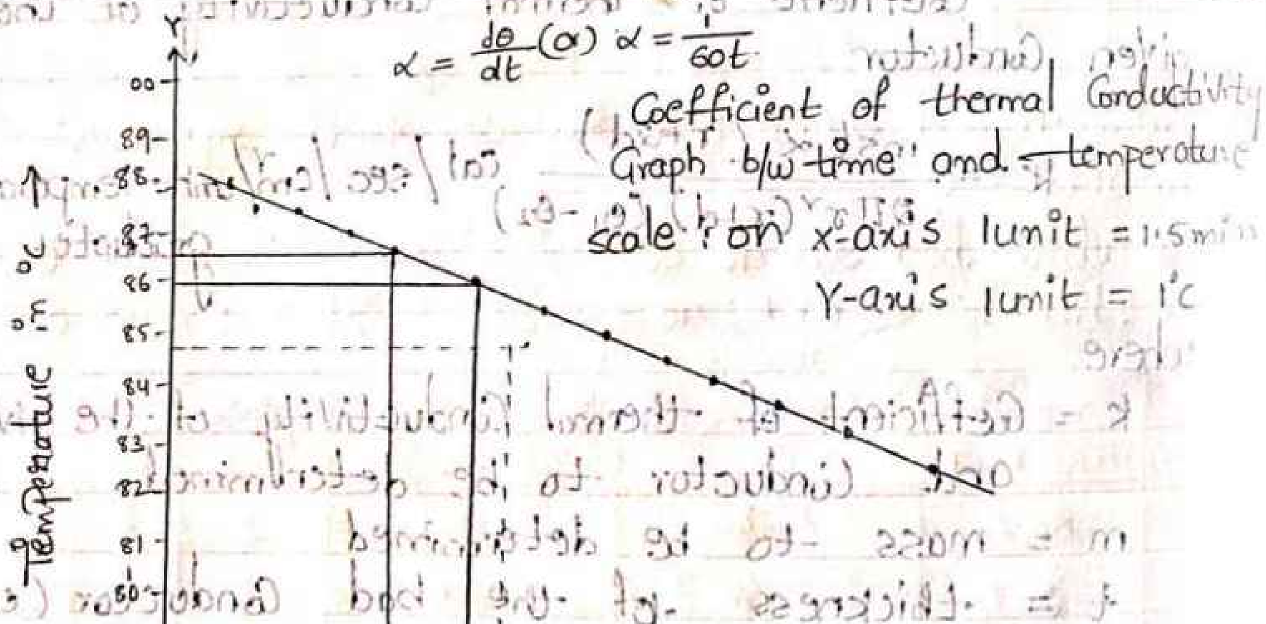
r = radius of the brass disc (cm)

Signature :

13


C
Steam outlet
Steam chamber
steam inlet
T_1
T_2
Thermometer
Bad conductor

Graph :-


$\alpha = \frac{d\theta}{dt}$ (or) $\alpha = \frac{1}{60t}$
Coefficient of thermal Conductivity
Graph b/w time and temperature
scale : on x-axis 1unit = 1.5 min
Y-axis 1unit = 1°C
Temperature in °C
Time (t) in minute
Y
X

14

S = specific heat of the material of the base disc [0,09 cal]
θ_1 = steady temperature of the steam Chamber °C
θ_2 = steady temperature of the brals disc °c
α = Rate of cooling at the study temperature on = $d\theta/dt$ [from the graph]

Description :-
lee's apporates consists of a thick nickel - Coals brass disc. A spended by three stings from a ring clamped to a stand; such that the faces of the disc such that faces of disc are the horizontal. The bad Conductor B is placed b/w the disc A and the cylindrical brass steam chamber All the there with a deep hole through. with a thermonter Can be inserted the note the temperaturel.

Procedure :-
steam separately generated from a steam generator is circuit through the cirmeter which gets heated is Conducted across the bad Conductor and those the braws A also get heated. After same time the there temperates θ_1 & θ_2 respectively. then Condition is reached heat

To determine of brass disc (d) :- [Vernier Callipers]

Value of one main scale divison = 1

Total number of devision on the V.C N =

least Count of the vernier L.C = S/N =

S.NO	M.S.R 'd' Cm	Vernier Coincidence (V.C)	Diameter D = a + (VC × L.C)
1			
2		6	
3			

Average diameter of the brass (d) =

Average diameter of the brass (r) =

To determine the thickness of brass disc (D) :-

Error :- Division Correction :+25 least Count

S.No	P.S.R 'a' Cm	Head Scale Reading Observed	Head Scale Reading Corrected	Thickness D = a + (x × L.C)
1.				
2.				
3.				

Average thickness of the brass D =

D =

To determine the thickness of the bad Conductor :

Zero Error :- Correction :

S.No	P.S.R 'a' Cm	Head Scale Reading Observed	Head Scale Reading Corrected	Thickness T = a + (x × L.C)

Average thickness of the bad Conductor (t) =

=

16

steady state remove the bad Conductor and place steam chamber c directly on the brass disc A. the temperature of the disc A. when the temperature of the disc A. rises by 5°c above the steady temperature of the brass disc watch minute until the temperature falls to a temperature 5°c below its steady temperature θ_2.

Graph :-

Draw a Cooling Curve with time on x-axis and temperature on Y-axis The rate of Cooling α of the brass disc at the steady temperature θ_2 Can be found by any of the two Method.

Method :-

All the study temperature θ_2 of the brass disc, draw a typel parallel to x-axis, which curve at the steady temperature θ_2 to the bases disc. Then, the rate of Cooling α at the Steady temperature Can be found by the Slope of the tangent i.e

$$\alpha = \frac{d\theta}{dt}.$$

Precautions :-

1. The thickness of bad Conductor should be

Signature :

17

Reading for cooling curve :-

Time in minutes	Temperature of distance r
0	[illegible]
0.5	[illegible]
1	[illegible]
1.5	[illegible]
2.0	[illegible]
2.5	[illegible]
3.0	[illegible]
3.5	[illegible]
4.0	[illegible]
4.5	[illegible]

$$K = \frac{mst\alpha(r+2d)}{2\pi r^2 (r+d)(\theta_1 - \theta_2)}$$

18

Date

Expt. No.

Page No. 12

thin and uniform.

2. study State temperature should be noted only when the reading of θ_1 and θ_2 remain Constant for about 5 min.

3. Thermometer should be placed to the focus of the bad Conductor on either side

4. The diameter of bad Conductor should be equal to that of A and C.

Result :-

Coefficient of thermal Conductivity of the bad Conductor.

$K =$ [illegible] cal/sec/cm^2/unit temperature Graduate

SEMESTER - III

1. Determination of heating efficiency of electric kettle - varying voltages.
2. Temperature characteristics of Thermistor.
3. Determination of Planck's constant.
4. Determination of mechanical equivalent of heat - by Joule's calorimeter.
5. Determination of Stefan's constant.
6. Bad conductor by Lee's Method.

20